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LIFE HISTORY OF *NEODIPRION FULVICEPS* (CRESSON), A PONDEROSA PINE FEEDING SAWFLY (HYMENOPTERA: DIPRIONIDAE)

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Abstract.—The life history of *Neodiprion fulviceps* Cresson, as a distinct species in the *Neodiprion fulviceps* complex, is described. The larvae feed on the foliage of ponderosa pine, *Pinus ponderosa* Dougl. ex Laws. Overwintering occurs as cocoons in the soil. There are four male and five female feeding larval instars. Development from egg hatch to adult emergence requires 47 days for males and 54 days for females. Behavioral characteristics of adults and larvae are described.

Conifer-feeding sawflies in the family Diprionidae are major economic pests of natural and plantation forests. Life histories for diprionid sawflies in eastern United States are well known (Wilson, 1977). However, pine feeding Diprionidae in western United States are not well understood. For example, of the five species of sawflies that feed on ponderosa pine, *Pinus ponderosa* Dougl. ex Laws., in Arizona, detailed life history information is available for only one species.

In addition to the paucity of basic biological information, the taxonomy of this group is confused. Ross (1955) groups several variable populations of sawflies feeding on pines into the *Neodiprion fulviceps* complex. Smith (see preceding paper in this journal) separates at least two species from the *N. fulviceps* complex: *N. fulviceps* and *N. autumnalis* Smith. Biological data on the *N. fulviceps* complex presented by Dahlsten (1961, 1966, 1967) is similar to our biological observations on *N. autumnalis*. It is likely that the *N. fulviceps* complex studied by Dahlsten (1961, 1966, 1967) is more closely related to *N. autumnalis* than *N. fulviceps*.

This paper reports preliminary biological information on *Neodiprion fulviceps* as a distinct species within the *N. fulviceps* complex.

Materials and Methods

Data were collected from and biological observations made on a single outbreak population of *N. fulviceps* located on the median strip of Interstate 40, south of Flagstaff, Arizona. The population was discovered in July 1982. The area was a typical ponderosa pine transition zone with pole-sized open grown trees.

Life history, adult and larval behavior.—Observations on the development stage of the insect and behavior were made on weekly visits to the infested area from July 1982 through July 1985. The earliest and latest observation of a particular life stage in the field, taken over the four year study period, were used to determine the life history.

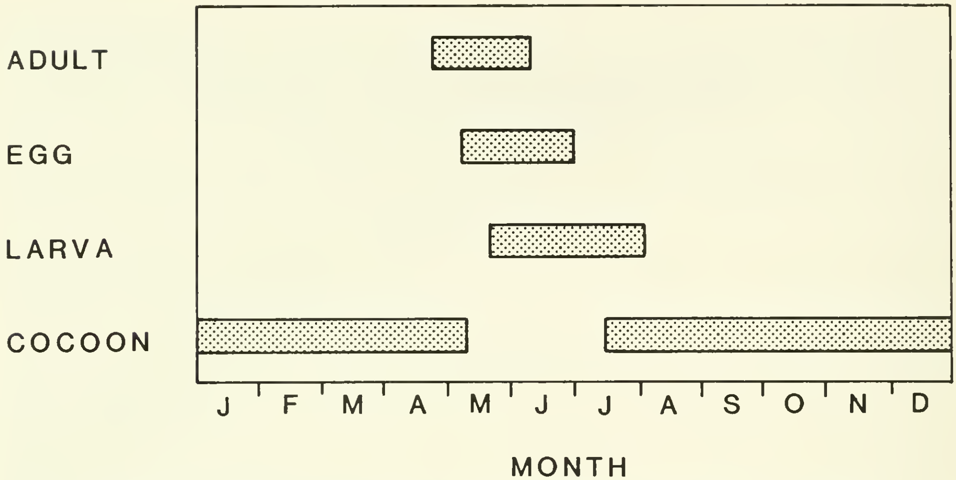

Fig. 1. Seasonal periods for *Neodiprion fulviceps* life stages in the field from 1982–1985.

Oviposition.—A sample of 50 needle clusters from 11 trees were collected and examined in June 1983. The following was noted for each egg cluster: needle length, number of eggs, presence or absence of a test slit and the number of needles in a fascicle that held eggs.

Larval instars and development.—Visits were made to the study area in May and June 1984 to determine the number of larval instars, average head capsule width for each instar and development time. At each visit, eggs were located and observed until hatching occurred. Newly hatched sawflies were carefully collected and placed in plastic rearing boxes for transport to the laboratory where the head capsule widths were measured with a microscope micrometer. Individual sawfly larvae were then placed in numbered petri dishes with fresh ponderosa pine foliage. Fresh foliage was supplied every other day. Petri dishes were kept in a Percival® temperature chamber at 25–27°C and photoperiod of 16 h light-8 h dark. Each sawfly was checked daily until it spun a cocoon. The date and the width of the head capsule were recorded following each molt. Numbered cocoons were transferred to a desiccation jar containing a small amount of water. As the adult sawflies emerged, they were sexed and transferred to a freezer for storage.

Results and Discussion

Life history.—Fig. 1 illustrates the periods during which various life stages of *N. fulviceps* have been observed in the field. These observations contrasted sharply with Dahlsten's (1961) description of the life history of the *N. fulviceps* complex where he reported that the adults emerge in the fall and the eggs overwinter. The life cycle differences between these species and the resulting reproductive isolation were the basis for initially questioning the species identification of this sawfly population. Subsequent taxonomic evaluation (see preceding paper) yielded sufficient morphological variation to allow separation of *Neodiprion fulviceps* as a distinct species within the *N. fulviceps* complex.

Adult behavior and oviposition.—Adult emergence began in late April and continued through the end of May. Males were active flyers and able to maintain

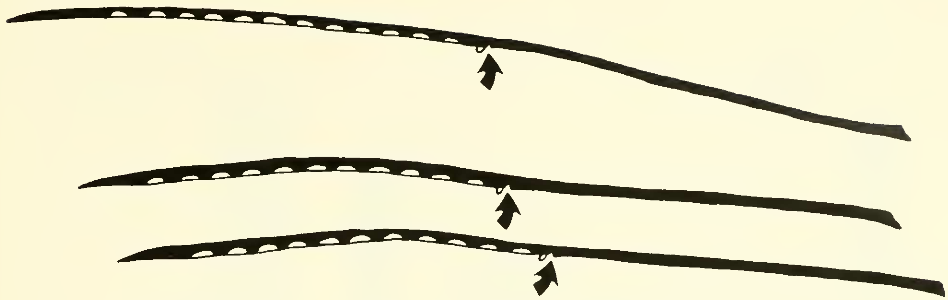

Fig. 2. Ponderosa pine needles with *Neodiprion fulviceps* eggs. Arrows indicate test slits cut by females.

flight in strong wind. The males were usually seen swarming around the outer crown of the tree. Females were rarely observed in flight; they were generally found either stationary or walking up and down needles on exposed twigs.

Very little courtship behavior was observed. A male that landed near a female immediately attempted to copulate. Males also attempted to mate with ovipositing females. In the laboratory, mating and oviposition occurred in as little as one hour after emergence of the female. Adults usually lived two to three days in the laboratory.

The adult female began oviposition by cutting a small slit near the base of the needle. Similar oviposition behavior has been described by Dahlsten (1961) for the *N. fulviceps* complex, and by Benjamin (1955) for *N. lecontei* Fitch. This small cut is referred to as a test slit (Fig. 2). The function of the test slit is unknown but it may be cut by the female to sever the resin duct or determine suitability of the needle for oviposition. The test slit was always made proximal to the part of the needle in which oviposition occurs. Of 68 individual needles containing eggs, 67 included test slits. The one needle that did not have a test slit was next to a needle that did have a test slit. Some needles were found with test slits and no eggs. Apparently, the female rejected some needles after sawing into them. Frequently, a drop of resin was observed where the test slit was cut into the needle.

Females laid an average of 10.81 eggs per needle (SE ± 3.99, range 1–18, n = 68). An average of one egg was laid for each 1.12 cm of needle length. Typically, eggs were oviposited only into the distal one half of each needle. Ponderosa pine usually has three needles per fascicle. Of the three-needle fascicles we evaluated, 86% had only one needle in the group with eggs and 14% had two needles in the group with eggs. Eggs were never found in all three needles of a fascicle.

Larval behavior.—The eggs split open and the larvae emerged from the eggs head first, usually facing the tip of the needle. This behavior was almost identical to that described by Ghent (1960) for *Neodiprion pratti banksianae* Rohwer. The whitish-yellow head capsule quickly darkens to a smokey grey color.

Early instar larvae fed as a group around individual needles facing the needle tip. As many as eight larvae were observed feeding at a single point on a needle. Only previous years' foliage was available to early instar larvae on the tree. During later instars, the current year's foliage was available but larvae rarely fed on it.

The initial outbreak of *N. fulviceps* occurred on what would be classified as

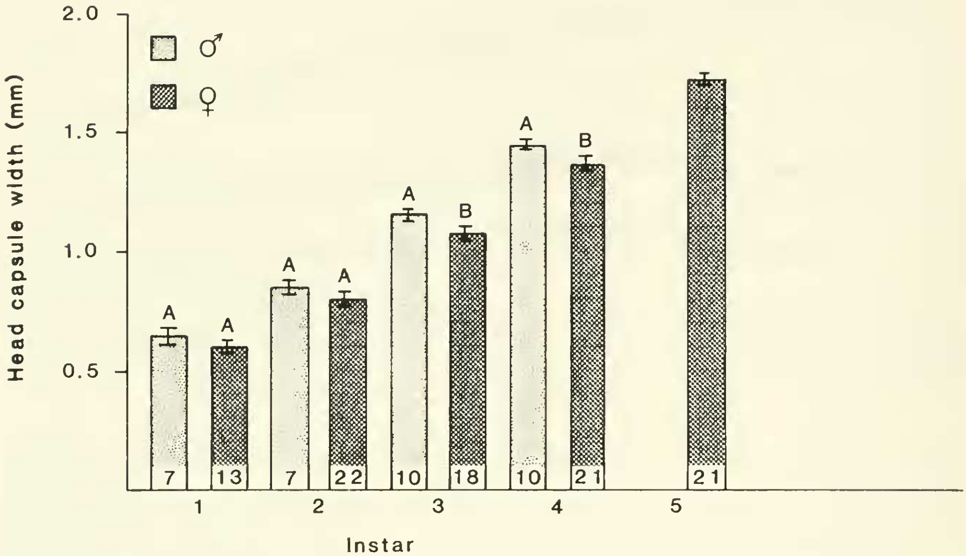

Fig. 3. Head capsule widths by instar for male and female *Neodiprion fulviceps* larvae. Bars indicate ± standard error of the mean. Different letters above the bars indicate significant differences between sex within an instar (ANOVA, $\alpha = 0.05$). Values at the base of bars indicate sample size.

typical sawfly susceptible trees, i.e. open grown pole-sized trees (dbh $\bar{x} = 9.1$ inches, SE = 3.71, range 5.5–16.6). In 1985, however, the infestation had expanded to include trees of a substantially larger size class (dbh = 26.6, SE = 3.78, range = 19.2–31.6). The expanded infestation occurred primarily on open grown trees as well. The ability of *N. fulviceps* to colonize large (older) trees may be unique among pine-feeding Diprionidae in the Southwest.

Pine-feeding Diprionidae are well known for their larval defensive behavior. Typically larvae rear their heads, often in unison, and emit a droplet of resin on a predator or parasite. This defensive behavior was observed for *N. fulviceps* in the early instars. In later instars, however, the typical defensive strategy was almost completely replaced by a quite strange behavior. When late instar larvae were disturbed they completely released their hold on feeding sites and dropped from the trees. We were able to collect larvae very easily by holding a container beneath a feeding branch and simply tapping the branch. This behavior was observed in the penultimate instar (last feeding instar) and the ultimate instar, but it was not determined if larvae that dropped from trees in this manner returned to the tree, ceased feeding and spun cocoons, or died.

Larval instars and development.—Rearing individual larvae from eclosion to adults indicated there are four feeding instars for the male and five feeding instars for the female (Fig. 3). The ultimate non-feeding instar, common in many sawfly species, also occurs in *N. fulviceps.* Because of the short duration of this nonfeeding instar, we did not measure the head capsule width. The third and fourth instar males were statistically larger than females.

The cumulative time in each of the main development stages was determined (Fig. 4). Males and females spent statistically equal amounts of time in the first

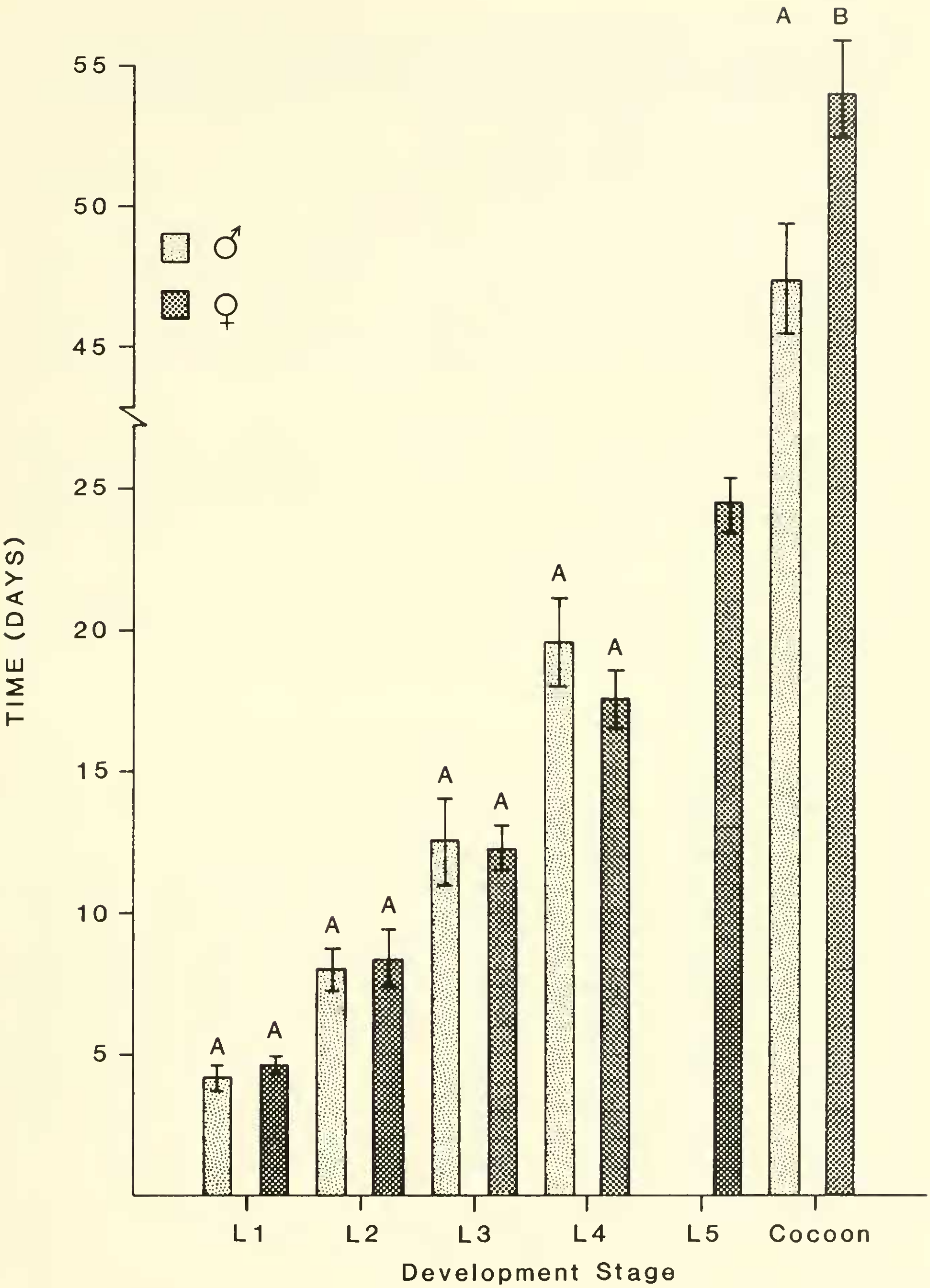

Fig. 4. Cumulative time from egg hatch to the end of selected development stages of *Neodiprion fulviceps* reared at 25–27°C. Bars indicate ± standard error of the mean. Letters above the bars indicate a significant difference between sexes within a development stage (ANOVA, $\alpha = 0.05$). Sample size: L 1–5, 6 males-11 females; cocoon, 3 males-6 females.

four instars. The adult females require 54.0 ± 1.63 days to complete development compared to 47.3 ± 1.67 days for males (based on smaller sample, n = 6,3 respectively). This explained the commonly observed early emergence of males. Males were in the cocoon stage approximately 27 days and females approximately 29 days.

The development periods reported in Fig. 4 are from 17 individuals (six males, 11 females) that were reared from first instar larvae to cocoon. The initial sample size was 60 larvae. Of the 60 larvae, 29 successfully spun cocoons (only 17 were used in the development study because the molting date was missed for some individuals). Of the 29 cocoons only nine emerged as adults during the study. The poor survival of individual larvae was probably due to the inability of individual larvae to initiate feeding sites on the ponderosa pine foliage. Colonial feeding by sawfly larvae is thought to be a mechanism of dealing with the tough needles; the first larva that successfully chews into the needle is typically joined by several others (Ghent, 1960). Thus, rearing larvae in isolation may contribute to low survival rates. The poor adult emergence was possibly due to low relative humidity in the rearing containers, or improper temperature or photoperiod during the larval period.

Acknowledgment

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Literature Cited

Benjamin, D. M. 1955. The biology and ecology of the red-headed pine sawfly. USDA Tech. Bull. 1118. 55 pp.

Dahlsten, D. L. 1961. Life history of a pine sawfly, *Neodiprion* sp., at Willits, California (Hymenoptera: Diprionidae). Can. Entomol. 93: 182–195.

———. 1966. Some biological attributes of sawflies in the *Neodiprion fulviceps* complex in a brushfield pine plantation. (Hymenoptera: Diprionidae). Can. Entomol. 98: 1055–1083.

———. 1967. Preliminary life tables for pine sawflies in the *Neodiprion fulviceps* complex (Hymenoptera: Diprionidae). Ecology 48: 275–289.

Ghent, A. W. 1960. A study of the group feeding behavior of the larvae of the jack pine sawfly, *Neodiprion pratti banksianae* Roh. Behavior 16: 110–148.

Ross, H. H. 1955. The taxonomy and evolution of the sawfly genus *Neodiprion*. For. Sci. 1: 196–209.

Wilson, L. F. 1977. A guide to insect injury of conifers in the Lake States. U.S. For. Serv., Agric. Handbook 501. 218 pp.